Chapter 3 – Need for Power Analysis

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3 Need for Power Analysis

In analyzing the need for power, TVA begins with its long-term forecasts of the growth in demand for electricity (for the purposes of this IRP, through 2029), both in terms of electricity sales to the end user, and the peak demands those end users place on the TVA system. It then identifies the current supply- and demand-side resources available to meet this demand. The final step is comparing the demand with supply and using the resulting gap to arrive at a need for generating assets or demand-side options.

3.1 Power Demand

3.1.1 Methodology

As discussed above, any determination of a need for power begins with a long-term forecast of energy sales and peak demand. These long-term forecasts are developed from individual, detailed forecasts of residential, commercial and industrial sales and serve as the basis for all planning, including generation and financial planning activities.

TVA's load forecasting is a complex process that starts with the best available data and is carried out using both econometric (statistical economic) and engineering, or end-use models. TVA's econometric models link electricity sales to several key economic factors (hence the term, econometric) in the market, such as the price of electricity, the price of competing energy source options like natural gas, as well as growth in overall economic activity (generally measured by changes in the Gross State Product). Specific values for key variables are used to develop forecasts of sales growth in the residential and commercial sectors, as well as in each industrial sector. Underlying trends within each sector, such as the use of various types of equipment or processes, play a major role in forecasting sales. To capture these trends and changes in the stock and efficiency of equipment and appliances, TVA uses a variety of end-use forecasting models. For example, in the residential sector, sales are forecast for space heating, air conditioning, water heating and several other uses after accounting for other important factors like changes in efficiency over time, appliance saturation and replacement rates, and growth in the average size of the American home. In the commercial sector, a number of end-use categories, including lighting, cooling, refrigeration and space heating, are examined with a similar attention to changes in other important variables like efficiency and saturation.

Forecasting is inherently uncertain, so TVA supplements its modeling with industry analyses and studies of specific major issues that have the potential to impact those forecasts. Further, TVA also produces alternative regional forecasts based on different outcomes for key drivers like economic growth, population growth, or economic behaviors of some of TVA's largest wholesale customers. Two of these alternative forecasts, referred to internally as the high and low load forecasts, define a range of possible future outcomes with a high level of confidence that the true outcome will fall within this range. This ensures that TVA's resource planning takes account of the variability that is the hallmark of year-on-year peak demand and energy sales.

As discussed above, several key inputs are used as drivers of the long-term forecasts of residential, commercial and industrial demand. The most important of these are economic activity, the price of electricity, customer retention, and the price of other sources of energy including natural gas.

Economic Activity

Periodically, but at least annually, TVA produces a forecast of regional economic activity for budgeting, long-range planning and economic development purposes. These forecasts are based on national forecasts developed by www.economy.com, an internationally recognized economic forecasting service.

The economy of the TVA service territory has historically been more dependent on manufacturing than the U.S. as a whole, with industries such as pulp and paper, aluminum, steel, and chemicals drawn to the region because of the wide availability of natural resources, reliable, competitively priced electricity, and access to a skilled workforce. In recent years, regional growth has outpaced national growth because manufacturing activities have grown at a faster pace than non-manufacturing activities. However, this can also mean that in periods of recession, regional growth will contract faster, and more sharply, given this relatively higher degree of dependence on manufacturing. The flip side of this, as has been evidenced by the recovery from the most recent recession, is that the regional economy also tends to recover more quickly and robustly.

Future growth is expected to be lower than historical averages as a result of the impacts of the recent recession and subsequent recovery as well as the trend of declining U.S. manufacturing. As markets for manufacturing industries have become global in reach, production capacity has moved from the TVA region overseas for many of the same reasons that the industries first moved to the TVA region. The contraction of these industries, and the load growth associated with them, has been offset to some degree by the growth of the automobile industry in the Southeast in the last 20 years. Although the TVA region is expected to retain its comparative advantage in the automotive industry, as exemplified by the new Volkswagen auto plant under construction in Chattanooga, Tennessee, reduced long-term prospects for the U.S. automotive industry will also have an impact on the regional industry.

Other impacts from the recent recession—increased financial market regulation, tighter credit conditions, as well as large federal budget deficits—may also work toward restraining growth. These changes could persist in the long term with the result being that overall economic growth for the TVA region and the nation being somewhat below TVA's previous expectations.

Population growth in the Valley, however, continues to be strong. Most migration into the region is still primarily driven by economic opportunities migration out of contracting sectors and into the Valley's expanding sectors. Part of this growth is to serve the existing population (retail and other services), but more importantly, a growing part is related to "export" services that are "sold" to areas outside the region. Notable examples are corporate headquarters such as Nissan and Hospital Corporation of America, which is the largest private operator of hospitals in the world, in Nashville; and FedEx, Autozone, International Paper, and Service Master in Memphis. In addition, the Tennessee Valley has become an attractive region for the growing ranks of America's retirees (increasingly fueled as Baby Boomers exit the workforce) looking for a moderate climate and a more affordable region than traditional retirement locations. The increase in retiree population has a multiplier effect in the service sector, increasing the need for employees to meet growing demand.

Price of Electricity

Forecasts of the retail price of electricity are based on long-term estimates of TVA's total costs to operate and maintain the power system adjusted to include an estimate of the historical markups charged by distributors. These costs, known in the industry as revenue requirements, are based on estimates of the key costs of generating and delivering electricity, including fuel, variable operations and maintenance costs, capital investment and interest. High and low electricity price forecasts are also derived using high and low values for these same factors after accounting for any relationships that may exist between variables.

Customer Retention

Over the last 20 years, the electric utility industry has undergone a fundamental change in most parts of the country. In many states, an environment of regulated monopoly has been replaced with varying degrees of competition. Wholesale open access (the rights of wholesale customers to buy power from generating utilities other than the utility that owns the transmission and distribution lines that serve them) is largely mandated by the Federal Energy Regulatory Commission (FERC).

While TVA has contracts with its 155 distributors of TVA power, it is not immune to competitive pressures. Those contracts with distributors allow distributors to give TVA notice of contract cancellation, after which they may procure power from other sources. Many of TVA's large directly served customers have the option to shift production from plants served by TVA to plants in other utility service territories, provided TVA's rates are not competitive with those of the utilities serving those territories. In the IRP Baseline forecast, TVA's price of electricity is expected to remain competitive with the rates of other utilities. As a result, the net impact of competition in the medium forecast is that TVA will retain the majority of its current customer base.

Price of Substitute Fuels

Electricity is a source of energy. The utility derived from consuming electricity can also be obtained using other sources of energy, where applications allow. If the price of electricity is not competitive with the price of other fuels, where those fuels can be utilized to provide the same energy services as electricity (i.e. water and space heating), customers may substitute away from electricity in the long term, and into cheaper sources of energy, where possible. The potential for this type of substitution to occur will depend on the relative prices of other fuels, as well as the physical capability to do so. For example, while consumers can take action to change out electric water heaters and replace electric heat pumps with natural gas furnaces, the ability to utilize another form of energy to power consumer electronics, lighting and many appliances is far more limited by current technology.

Changes in the price of TVA's electricity compared to the price of natural gas and other fuels will influence consumers' choices of appliances—either electric, gas or other fuels. While other substitutions are possible, natural gas prices serve as the benchmark for determining substitution impacts in the load forecasts.

3.1.2 Forecast Accuracy

Forecast accuracy is generally measured in part by error in the forecasts, whether day ahead, year ahead, or multiple years ahead. Figures 3-1 and 3-2 show annual forecasts from 2000 through 2009 for net system requirements and peak load requirements as compared to actual energy use and peak loads, respectively. The mean annual percent error (MAPE)[1] of TVA's forecast of net system energy requirements for the 2000-2009 period was 1.9% and 2.8% for peak load requirements. These include large errors in 2009 as the ramifications of the 2008 financial crisis and resulting economic slowdown affected the remainder of the economy. In the TVA service area, the most significant reductions were in the industrial sector, and it has already begun to show signs of recovery. The 2000-2008 MAPE was 1.1% for net system requirements and 2.2% for peak load, which is more representative of the accuracy of TVA year-in and year-out load forecasts. Though TVA has not conducted a formal benchmark on this metric, from conversations with other utilities at conferences and working groups, our MAPE's appear to be in line with others', which is around 1-2%.

As mentioned above under Economic Activity, while the economy in the Valley may be slightly stimulated by the creation of "export" services sold to areas outside the TVA region, future growth is expected to be lower than historical averages as a result of a number of factors, including the impacts of the recent recession and subsequent recovery, the trend of declining U.S. manufacturing, and the projected loss of some TVA customer load.

[1] MAPE is the average absolute value of the error each year; it does not allow over-predictions and under-predictions to cancel each other out.

Figure 3-1 and Figure 3-2 indicate the magnitude of the downturn of TVA net system requirements and summer peak loads due in part to the recession in the region. Figure 3-1 is a comparison of actual and forecasted net system requirements expressed in total annual energy (GWh). Figure 3-2 is a comparison of actual and forecasted summer peak demand in MW's.

The trends shown in Figures 3-1 and 3-2 are the result of a decline in energy usage by TVA customers, due to a combination of factors including changes in the regional economy, improved efficiency and rising prices. Note also that the "Norm. Actual" line represents the normalized value of the annual energy, meaning abnormal weather impacts have been removed.

Figure 3-1 – Comparison of Actual and Forecasted Net System Requirements

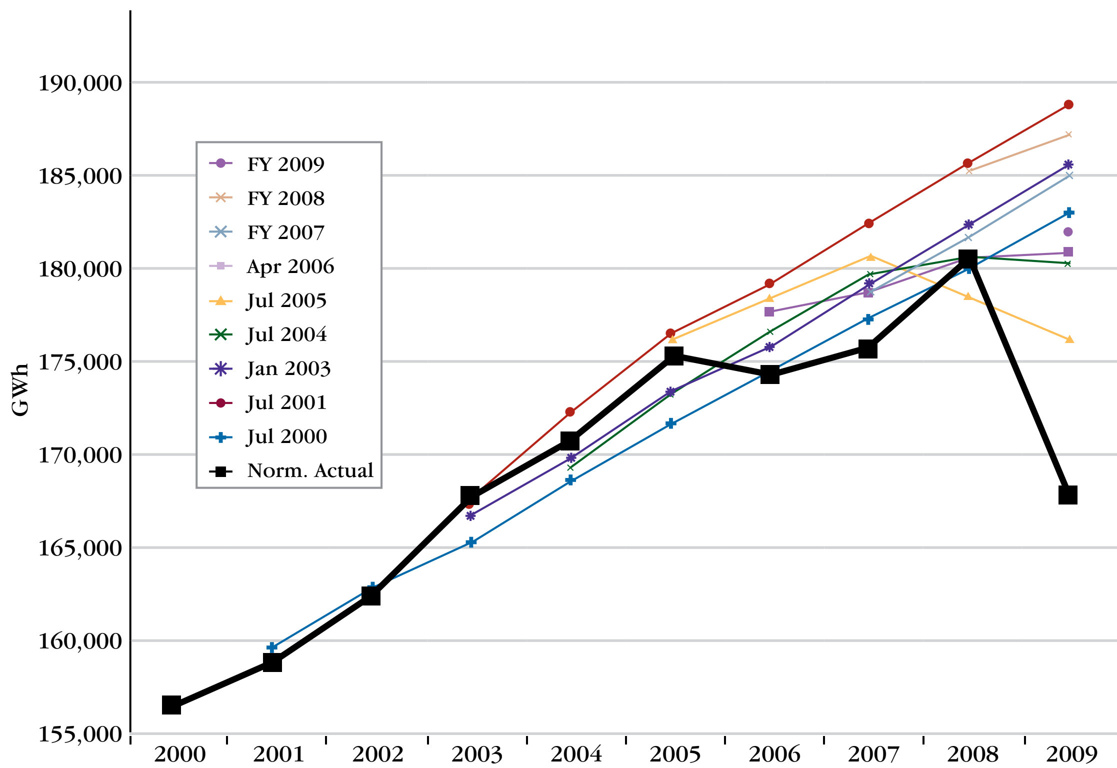
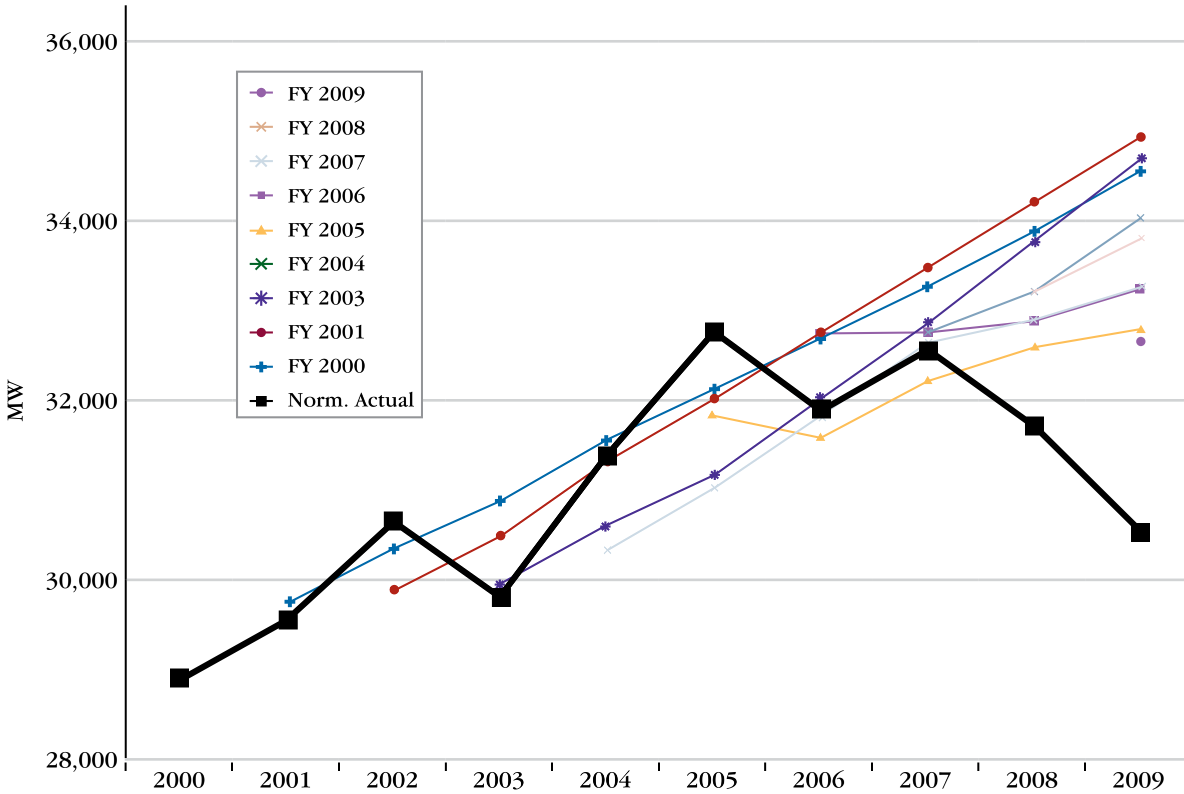


Figure 3-2 – Comparison of Actual and Forecasted Summer Peak Demand



3.1.3 Forecasts of Peak Load and Net System Requirements

To deal with the uncertainty inherent in forecasting, TVA has developed a range of forecasts, with each forecast corresponding to a different load scenario. Scenarios are described in Chapter 5. Forecasts of net system peak load and energy requirements for the IRP Baseline and the highest and lowest scenarios are shown in Figures 3-3 and 3-4, respectively. Peak load grows at an average annual rate of 1.3% in the IRP Baseline, varying from 0% in the lowest scenario to 2% in the highest scenario. Net system energy requirements grow at an average annual rate of 1% in the IRP Baseline, varying from 0% in the lowest scenario to 1.9% in the highest scenario.

The use of ranges ensures that TVA considers a wide spectrum of electricity demand in its service territory and reduces the likelihood that its plans are too dependent on the achievement of single point estimates of demand growth that make up the midpoints of the forecasts. These ranges are used to inform planning decisions beyond pure least-cost considerations given a specific demand in each year.

The IRP Baseline is impacted by the recent recession that slowed load growth in the short-term and adds uncertainty to the forecast of power needs; however, economic recovery is expected and future power needs are expected to grow but at a rate lower than historical averages.

Figure 3-3 – Peak Load Forecast

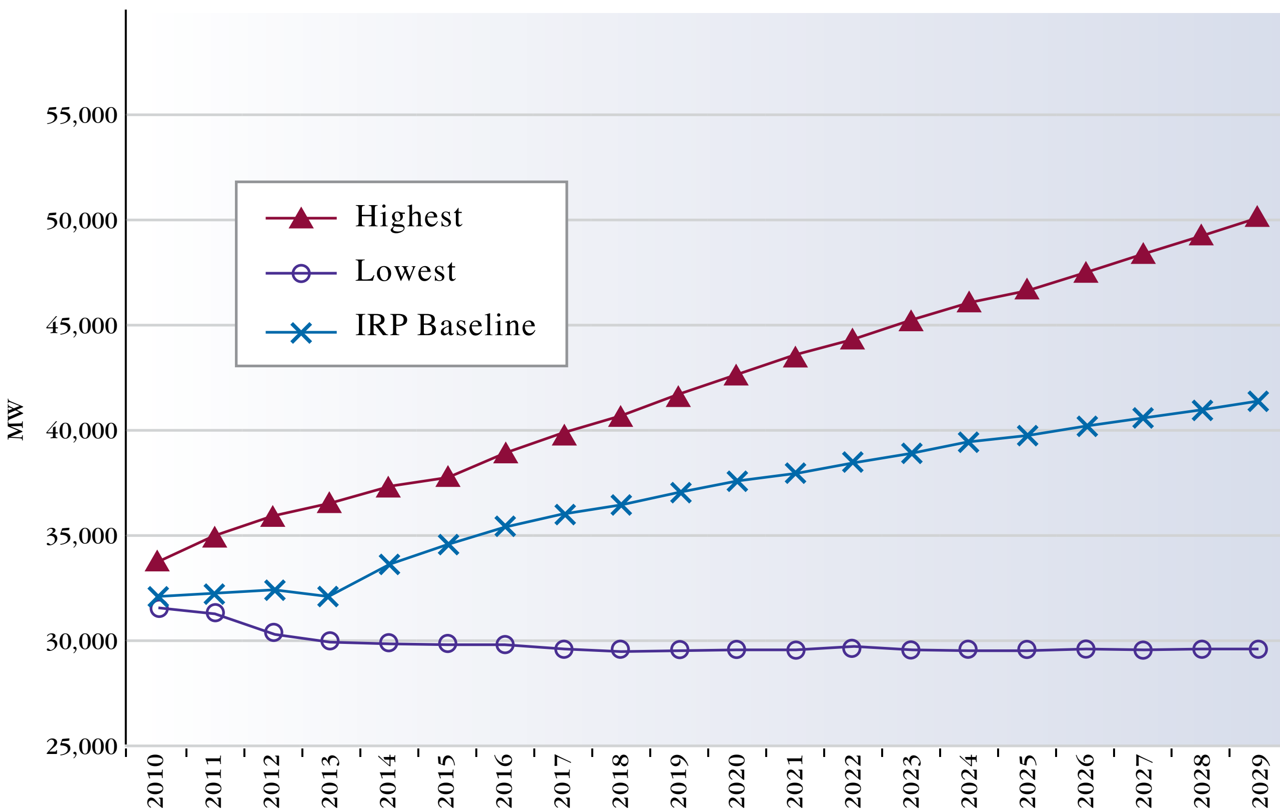
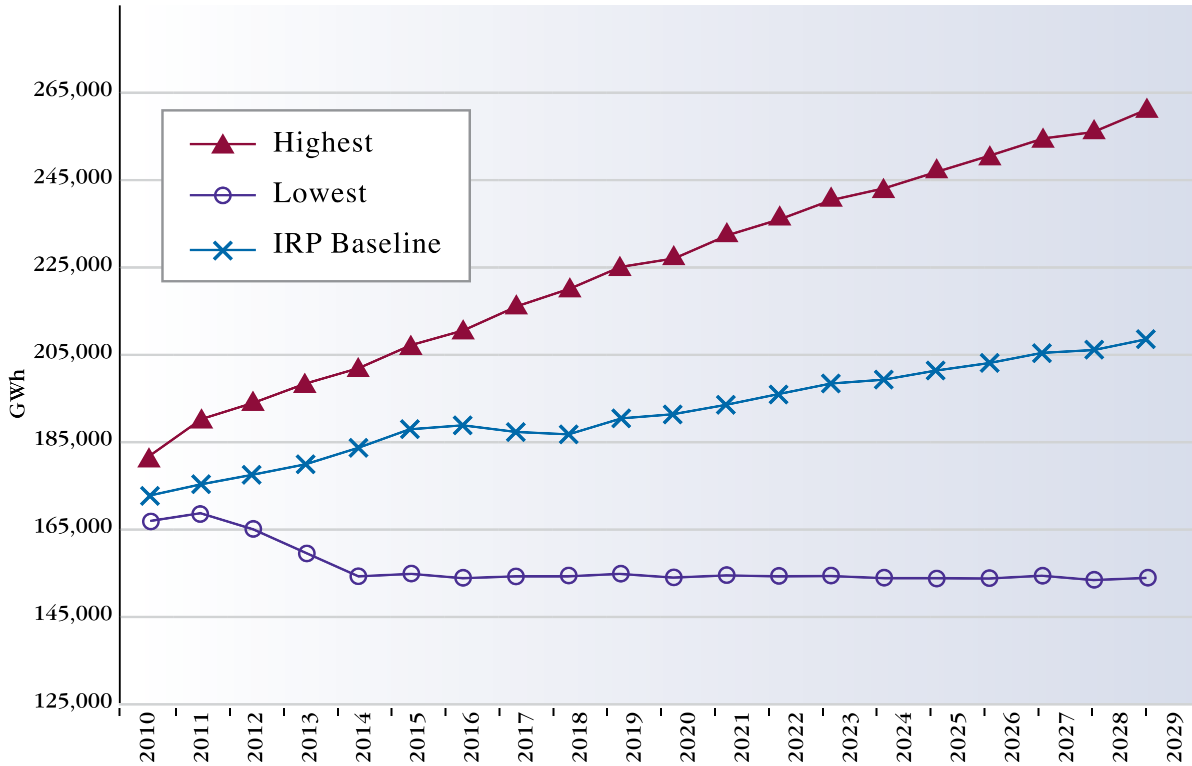


Figure 3-4 – Energy Forecast



3.2 Power Supply

TVA's generation supply consists of a combination of existing TVA-owned resources, budgeted and approved projects (such as new plant additions and uprates to existing assets), and power purchase agreements (PPAs) that give TVA a contractual right to the capacity and output of generating assets not owned by TVA. This supply includes a diverse portfolio of coal, nuclear, hydroelectric, natural gas and oil, market purchases, and renewable resources designed to provide reliable, low cost power while minimizing the risk of disproportionate reliance on any one type of resource. Each type of generation can be categorized based on its degree of utilization for supplying base load, intermediate, peaking or storage generation. Generation can also be categorized by capacity, energy type and how it is measured.

Figure 3-5 – Illustration of Peaking, Intermediate, and Base load Resources

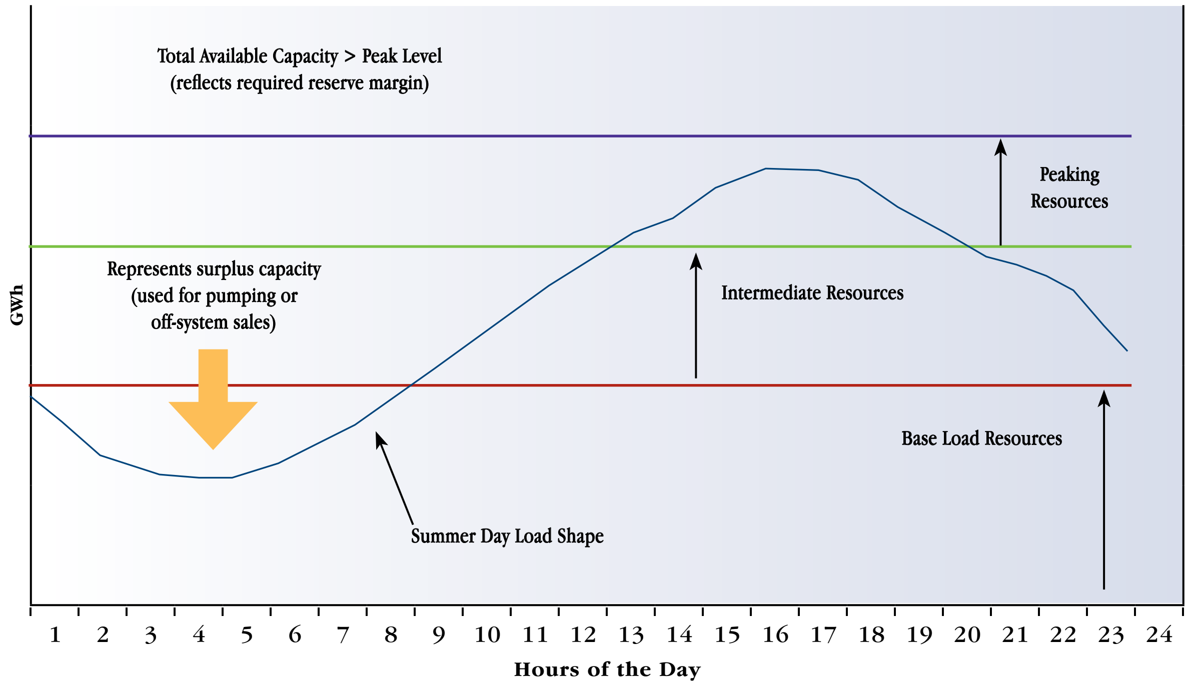


Figure 3-5 illustrates the uses of peaking, intermediate and base load generation. Although these categories are useful, the distinction between them is not always clear-cut. For example, a peaking unit may be called on to run continuously for some time period like a base load unit, although it is less economical to do so. Similarly, many base load units are capable of operating at different power levels, giving them some of the characteristics of an intermediate or peaking unit. This IRP considers strategies that take advantage of this range of operations.

3.2.1 Base Load Resources

Base load generators are primarily used to meet continuous energy needs because they have lower operating costs and are expected to be available and operate continuously throughout the day. These base load resources typically have high capital costs, but these higher capital costs are usually offset by favorable fuel costs, especially when fixed costs are expressed on a unit basis. This type of energy is generated from technologies that can provide continuous, reliable power over long periods of uniform demand, such as base load coal plants and nuclear reactors. Some energy providers may consider combined-cycle plants for incremental base load generation needs; however, given the tendency for natural gas prices to be higher than coal and nuclear fuel prices, combined cycles may be a more expensive option for larger continuous generation needs, at least given recent fuel prices. As the fundamentals of fuel supply and demand change in the future, and as access to shale gas continues to grow, this relationship may change in the future.

3.2.2 Intermediate Resources

Intermediate resources are primarily used to fill the gap in generation between base load and peaking needs. These units are required to produce more or less output as the energy demand increases and decreases over time (usually during the course of a day). Intermediate units are more costly to operate than base load units but cheaper than peaking units. This type of generation typically comes from natural gas-fired combined cycle plants and smaller coal plants. Corresponding back-up balancing supply needed for intermittent renewable generation (such as wind or solar) also comes from intermediate resources. It is possible to use the energy generated from a solar or wind project as an intermediate resource with the use of energy storage technologies.

3.2.3 Peaking Resources

Peaking units are only expected to operate infrequently, mainly during shorter duration, high demand periods. They are essential for maintaining system reliability requirements, as they can ramp up quickly to meet sudden changes in either demand or supply. Typical peaking resources include natural gas-fired combustion turbines (CTs), conventional hydroelectric generation and pumped-storage, and renewable resources.

3.2.4 Storage Resources

Storage units usually serve the same power supply function as peaking units, but use low cost off-peak electricity to store energy for generation later at peak times. An example of a storage unit is a hydro pumped-storage plant that pumps water to a reservoir during periods of low demand and releases it to generate electricity during periods of need. Consequently, a storage unit is both a power supply source and an electricity user.

3.2.5 Capacity and Energy

Power system peaks are measured in terms of capacity (e.g. MW), which is the instantaneous maximum amount of energy that can be supplied by a generator. For long term planning purposes, capacity can be specified in many forms, such as nameplate (the maximum design generation), dependable (the maximum that can typically be expected in normal operation), seasonal (the maximum that can be expected during different seasons of the year) and firm (dependable capacity less all known adjustments).

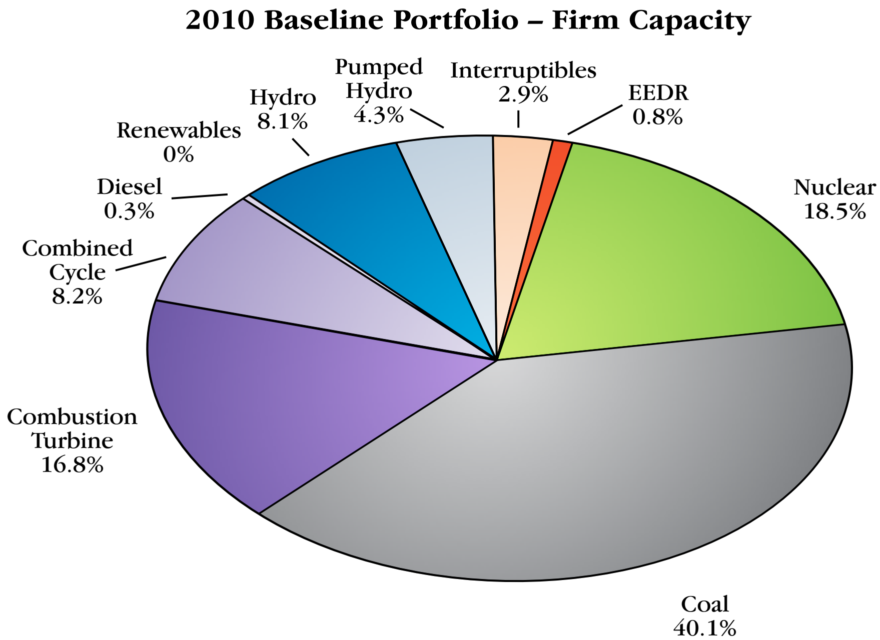
Overall power system usage is measured in terms of energy (e.g. MWh or GWh). Energy is the total amount of power that an asset delivers in a specified time frame. For example, one MW of power delivered for one hour equals one MWh of energy. Capacity factor is a measure of the actual energy delivered by a generator compared to the maximum amount it could have produced. Assets that are run constantly such as nuclear or fossil plants provide a significant amount of energy (higher capacity factor). Assets that are used infrequently such as combustion turbines provide relatively little energy (low capacity factor), although the energy they do produce is usually valuable since it often is delivered at peak times.

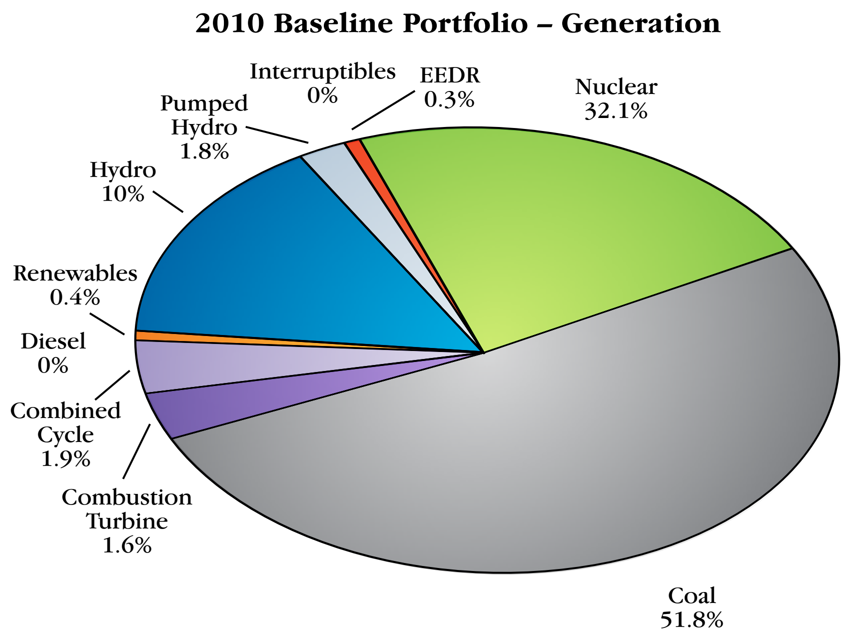
Energy efficiency measures can also be measured in terms of capacity and energy. Even though energy efficiency does not input power into the system, the effect is similar as it represents power that is not required. Demand reduction is also measured in capacity and energy, but unlike energy efficiency, it is not a reduction in total energy used.

3.2.6 TVA's Generation Mix

TVA's power generation system employs a wide range of technologies to produce electricity and meet the needs of the Tennessee Valley's more than nine million residents, businesses and industries. See Figure 3-6 for a breakdown of capacity and generation by technology for TVA's baseline portfolio. Note that for purposes of this IRP, the baseline portfolio is the long-term financial plan that was current as of spring 2010.

Figure 3-6 – Firm Capacity and Generation Mix

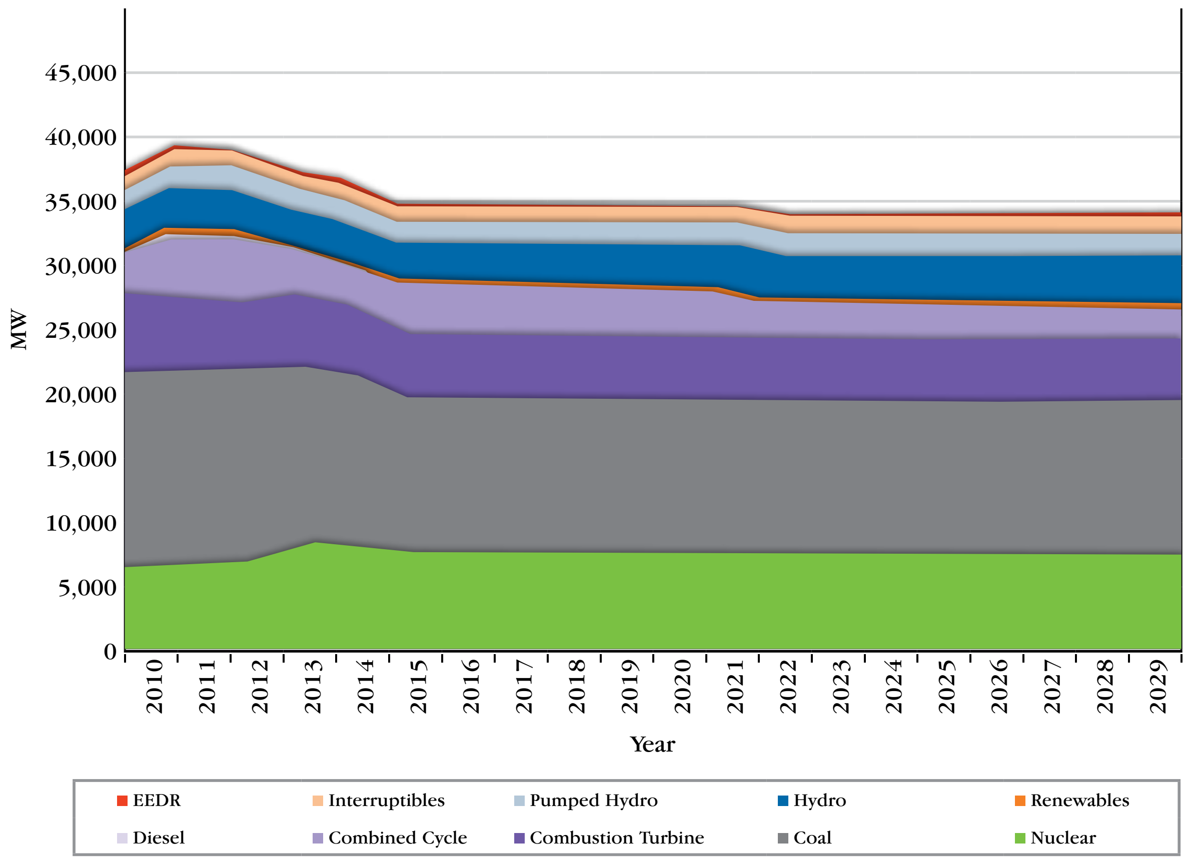




In 2010, approximately 55% of TVA's electricity will be produced from coal and natural gas-fired plants (51.8% coal; 3.5% gas). Nuclear plants will produce about 32%, hydroelectric plants will produce approximately 12%, and most of the remaining generation will come from renewable sources. TVA's EEDR programs are also in place for avoided generation.

Figure 3-7 illustrates the changing composition of existing generating resources that are currently anticipated or "planned" (assumed in planning) to be operated through 2029. Figure 3-7 includes only those resources that currently exist or are under contract (such as PPAs and EEDR programs) and changes to existing resources that are planned and approved. The total capacity of existing resources decreases through 2029, primarily because of the potential lay-up of approximately 2000 MW of coal-fired capacity. Total capacity also decreases as PPAs expire. The renewable energy component of the existing portfolio is primarily composed of wind PPAs, which are discussed in Chapter 4. The current EEDR programs are 0.8% of the capacity and are explained in further detail in Chapter 4. As discussed in Section 6, all IRP strategies include additional renewable resources and EEDR programs beyond those depicted in Figure 3-7.

Figure 3-7 – Baseline Capacity Portfolio



3.3 Assessment of Need for Power

The TVA system is dual-peaking, with high levels of demand occurring in both the summer and winter months. The annual peak demand in 2008 and 2009 occurred in January with the 2009 demand reaching over 32,500 MW. Winter peaks are expected to continue for the next couple of years; thereafter, the forecasted peak load or the highest demand placed on the TVA system is projected to occur in the summer months.

To ensure that enough capacity is available to meet peak demand, including contingency for unforeseen events, additional generating capacity beyond that which is needed to meet peak demand is generally maintained. This additional generating capacity (known as “reserve capacity” or “operating reserves”) must be large enough to cover the loss of the largest single operating unit (contingency reserves), be able to respond to moment-by-moment changes in system load (regulating reserves) and replace contingency resources should they fail (replacement reserves). Total reserves must also be sufficient to cover uncertainties such as unplanned unit outages; load forecasting error, including the difference between actual weather and forecast; normal weather; and undelivered purchased capacity.

TVA identifies a planning reserve margin based on minimizing overall cost of reliability to the customer. This reserve margin is based on a stochastic analysis that considers the uncertainty of weather, economic growth, unit availability and transmission capability to compute expected reliability costs. From this analysis a target reserve margin is selected such that the cost of additional reserves plus the cost of reliability events to the customer is minimized. This target (optimal) reserve margin is adjusted based on TVA’s risk tolerance to produce the reserve margin used for planning studies. Based on this methodology, TVA’s current planning reserve margin is 15% and is applied during both the summer and winter seasons.

That capacity gap is defined as the difference between the existing firm capacity from the IRP baseline case (shown in Figure 3-7) and the load forecasts (shown in Figure 3-3) adjusted for any interruptible customer loads plus reserve requirements. In other words, the capacity gap is the difference between total supply and total demand. Net system requirement is the required energy needed to serve the load over the entire year. It includes the energy consumed by the end users plus distribution and transmission losses. The need for power can be expressed in two ways: (1.) capacity gap in MW, which is the instantaneous generation gap during the peak hour of the year; and (2.) the energy gap in GWhs, which is the amount of energy provided by the new resources added in the baseline case that is needed to meet net system requirements after considering the contributions from existing resources.

Figure 3-8 shows the resulting capacity gaps based on the IRP Baseline peak load forecast, as well as the range corresponding to the highest and lowest scenario. Figure 3-8 shows the same comparison for the energy gaps. Figures 3-8 and 3-9 reflect the assumptions included in the IRP Baseline case (see Section 5.3 for details about these assumptions). These figures also show that, under most scenarios and in most years, TVA requires additional capacity and generation, or EEDR, to meet or offset forecasted capacity and energy needs. The IRP Baseline need for additional generating capacity, or EEDR programs, is 9,600 MW and 29,000 GWhs of additional generation in 2019, growing to 15,500 MW and 45,000 GWhs in 2029.

Section 6 addresses the alternative strategies by which TVA could acquire additional capacity and generation, including EEDR programs, to meet the need for power shown in Figures 3-8 and 3-9.

Figure 3-8 – Capacity Gap

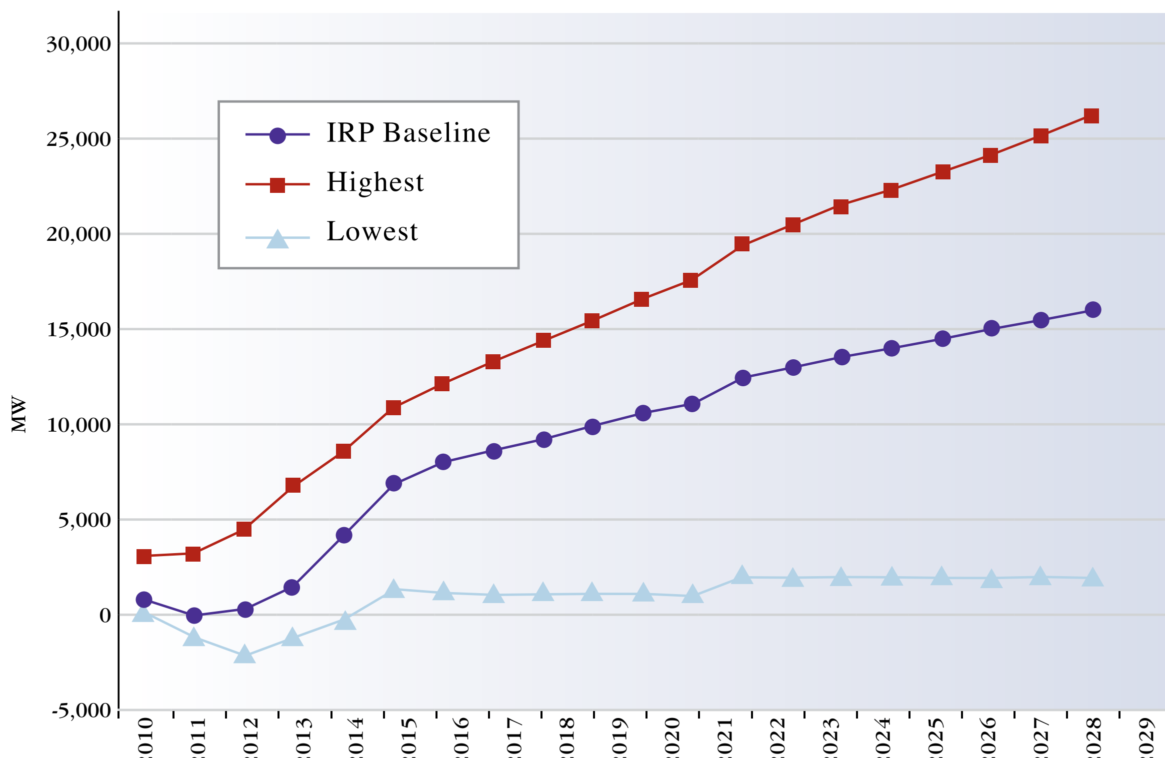


Figure 3-9 – Generation Gap